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Classification of combined partial knee arthroplasty

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Aims

There has been a recent resurgence in interest in combined partial knee arthroplasty (PKA) as an alternative to total knee arthroplasty (TKA). The varied terminology used to describe these procedures leads to confusion and ambiguity in communication between surgeons, allied health professionals, and patients. A standardized classification system is required for patient safety, accurate clinical record-keeping, clear communication, correct coding for appropriate remuneration, and joint registry data collection.

Materials and Methods

An advanced PubMed search was conducted, using medical subject headings (MeSH) to identify terms and abbreviations used to describe knee arthroplasty procedures. The search related to TKA, unicompartmental (UKA), patellofemoral (PFA), and combined PKA procedures. Surveys were conducted of orthopaedic surgeons, trainees, and biomechanical engineers, who were asked which of the descriptive terms and abbreviations identified from the literature search they found most intuitive and appropriate to describe each procedure. The results were used to determine a popular consensus.

Results

Survey participants preferred "bi-unicondylar arthroplasty" (Bi-UKA) to describe ipsilateral medial and lateral unicompartmental arthroplasty; "medial bi-compartmental arthroplasty" (BCA-M) to describe ipsilateral medial unicompartmental arthroplasty with patellofemoral arthroplasty; "lateral bi-compartmental arthroplasty" (BCA-L) to describe ipsilateral lateral unicompartmental arthroplasty with patellofemoral arthroplasty; and tri-compartmental arthroplasty (TCA) to describe ipsilateral patellofemoral and medial and lateral unicompartmental arthroplasties. "Combined partial knee arthroplasty" (CPKA) was the favoured umbrella term.

Conclusion

We recommend bi-unicondylar arthroplasty (Bi-UKA), medial bicompartmental arthroplasty (BCA-M), lateral bicompartmental arthroplasty (BCA-L), and tricompartmental arthroplasty (TCA) as the preferred terms to classify CPKA procedures.

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Combined partial knee arthroplasty (CPKA) is witnessing a resurgence in interest, with 67 bicompartmental knee publications in PubMed in the last decade, compared with just eight in the period between 1998 and 2008. This still represents less than 0.5% of the 18 063 knee surgery publications over the past decade. Treating multi-compartment arthrosis with a combination of small implants is not new and was developed in the early 1970s[1,2] at the same time as total knee arthroplasty (TKA).[3] Ever since, the combination of small implants has offered a bone- and cruciate-preserving alternative to TKA. Such procedures can be performed in the primary setting, simultaneously implanting multiple partial knee arthroplasties into the same knee under a single anaesthetic. However, a knee that has previously undergone unicompartmental or patellofemoral arthroplasty could develop arthrosis in one of the remaining compartments. For these knees, a compartmental approach would be to leave the original implant *in situ* and address only the newly degenerate compartment through the addition of a second partial knee implant.

Using combinations of unicompartmental and patellofemoral implants to resurface damaged compartments in a targeted manner produces four possible implant configurations: 1) medial and lateral unicompartmental arthroplasty; 2) medial

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Table I. Number of articles identified through a PubMed medical subject headings (MeSH) and advanced search of titles or abstracts containing descriptive terms for knee surgery; data accessed 19 November 2018

Search terms ("AND knee")	"AND arthroplasty", n	"AND replacement", n	"AND arthroplasty AND replacement". n
MeSH terms			
Knee	23 463	11 529	3996
Total	19,195	8302	3470
Partial	435*	318*	103*
Unicompartmental	1429	587	322
Unicondylar	326	157	95
Uni-compartmental	12	6	4
Non-MeSH terms			
Patellofemoral	945	379	210
Small implants	2	3	1
Combined partial	34	1	0
Compartmental	89*	36*	15
Multi-compartment	1	0	0
Bi-compartmental	11	7	2
Bicompartmental	83	51	32
Bi-unicondylar	2	2	0
Biunicondylar	2	2	0
Bi-unicompartmental	4	5	2
Biunicompartmental	4	5	2

*Search revealed a small number of unrelated articles

with patellofemoral arthroplasty; 3) lateral with patellofemoral arthroplasty; and 4) medial and lateral with patellofemoral arthroplasty. At present, there are a variety of terms and abbreviations used in the literature when referring to these procedures, which leads to confusion.

The purpose of this study was to identify variants in terminology, descriptive terms, or abbreviations for CPKA, and then to use the most intuitive language in order to create a contemporary classification system. Failure to refer to this group of procedures in a consistent and accurate way is a potential patient safety issue, as patients and healthcare professionals need to be clear as to exactly which procedure is planned, or has been performed, to provide safe and appropriate perioperative care. Also, clinical records must be clear regarding which implant, or combination of implants, the patient has *in situ*, thus ensuring the hospital is remunerated appropriately for the treatment provided. Furthermore, surgeons and joint registries must be able to accurately log and account for these procedures to enable rigorous audit of outcomes.

Materials and Methods

An initial search using medical subject headings (MeSH), the National Library of Medicine's controlled vocabulary thesaurus, was undertaken to determine whether accepted terminology existed for these procedures. An advanced search of PubMed (United States National Library of Medicine National Institutes of Health) was undertaken to identify key descriptive terms relating to surgery of the knee. The advanced search included all titles and abstracts. The first search used the (<search term> AND knee AND arthroplasty), the second looked for (<search term> AND knee AND replacement), and the final was for (<search term> AND knee AND arthroplasty AND replacement) to identify any publications where the terms are used interchangeably. The chosen search terms, for the advanced search, were those identified from the MeSH search: knee; total; unicompartmental; partial; unicondylar; in addition to patellofemoral; uni-compartmental; small implants; combined partial; compartmental; multi-compartment; bi-compartmental; bicompartmental; bi-unicondylar; biunicondylar; bi-unicompartmental; and biunicompartmental, which had not been identified in the MeSH search but considered relevant. The number of articles identified by the search was recorded. The PubMed advanced search function identifies only the articles which match all specified criteria, hence, a search for "knee arthroplasty" and "knee replacement" would identify only the articles that contained both terms.

The PubMed results were then sorted and filtered using the best match function to identify papers according to the search (bi-compartmental OR bicompartmental OR bi-unicondylar or bi-unicompartmental) AND knee AND (arthroplasty OR replacement). The top 15 papers were reviewed in full to determine the name given to each implant configuration, the abbreviation used, and whether the authors made a clear distinction between the use of a medial or lateral unicompartmental prosthesis when implanted in combination with patellofemoral arthroplasty.

The six terms and abbreviations used most commonly in the literature were then employed to create a survey, together with illustrations and radiographs demonstrating each combined arthroplasty procedure. Participants were asked to identify the one descriptive term and one abbreviation they felt were most intuitive for each procedure and for the combined procedures depicted by the illustration and radiographs. The survey was first circulated among 30 orthopaedic specialty registrars attending a training day. From their answers, a rationalized survey, using the top four preferred terms and abbreviations, was created. The second survey was conducted at the International Society for Technology in Arthroplasty annual congress, held in London, United Kingdom. A total of 200 surgeons and biomechanical engineers with a specialist interest in arthroplasty were invited to participate. The collective results were used to form a consensus regarding the most appropriate and intuitive terminology for each procedure.

Results

The PubMed MeSH and advanced searches were undertaken on 19 November 2018. The MeSH search focused on "arthroplasty, replacement, knee" and revealed 31 entry terms including arthroplasties, replacement, knee, total, partial, unicompartmental, and unicondylar. The accepted MeSH search terms made no reference to patellofemoral arthroplasty or multiple partial knee arthroplasties used in combination in the same knee. The advanced search used the identified MeSH search terms, in addition to terms related to CPKA, and revealed that while both the terms "arthroplasty" and "replacement" were common, the term "arthroplasty" was used more frequently (Table I). No clear distinction between the terms was found; 3996 articles were found to have used both terms within the same title or abstract.

Table II. Terminology and abbreviations used in the orthopaedic literature relating to combined partial knee arthroplasty

Publication	Medial and lateral unicompartmental; name (abbreviation)	Medial uni and patellofemoral arthroplasty; name (abbreviation)	Lateral uni and patellofemoral arthroplasty; name (abbreviation)	Clear distinction medial/lateral
Parratte et al[6] (2015)	Bi-Uni (Bi-Uni)	Bicompartmental (BKA)	Bicompartmental (BKA)	No
Sabatini et al[12] (2016)	N/A	Bicompartmental (BKA)	Bicompartmental (BKA)	No
Confalonieri et al[4] (2016)	Bi-Unicompartmental (Bi-UKA)	Bicompartmental (UKA+ PFA)	Bicompartmental (UKA+PFA)	No
Pandit et al[11](2017)	Bi-Compartmental (Bi-UKA)	N/A	N/A	N/A
Ma et al[8] (2017)	Bicompartmental (Bi-Uni)	Bicompartmental (BKA)	Bicompartmental (BKA)	No
Wünschel et al[13] (2011)	N/A	Bi-compartmental (BKA)	N/A	No
Thienpont and Price[10] (2013)	Bicompartmental (Bi-Uni)	Bicompartmental (BKA)	Bicompartmental (BKA)	No
Heyse et al[14] (2014)	N/A	Bicompartmental (BKA)	N/A	No
Chung and Min[15] (2013)	N/A	Bicompartmental (BKA)	Bicompartmental (BKA)	No
Yeo et al[16] (2015)	N/A	Bicompartmental (BCA)	N/A	No
Parratte et al[9] (2010)	Bicompartmental UKA (Bi-UKA)	Bicompartmental (med-UKA/PFA)	N/A	Yes
Spinelli et al[7] (2010)	Bi-Unicondylar (Bi-UKA)	N/A	N/A	N/A
Wang et al[17] (2018)	N/A	Bi-Compartmental (BKR)	N/A	No
Kamath et al[18] (2014)	N/A	Bicompartmental (BiKA)	Bicompartmental (BiKA)	No
Romagnoli et al[5] (2015)	Bi-unicompartmental (bi-UKR)	Combined uni and patellofemoral replacement (UKR+PFR)	Combined uni and patellofemoral replacement (UKR+PFR)	No

N/A, not applicable

A single implant resurfacing one tibiofemoral compartment was referred to as a "unicondylar", "uni-compartmental", and "unicompartmental" procedure, although the latter was more frequent. The use of a hyphen was variable, more common in historical papers, and its use appears to have diminished with time. Partial knee arthroplasty (PKA) served as a commonly used umbrella term for procedures other than TKA, although the search did return papers referring to "partial tendon ruptures" or "partial cartilage loss" in relation to total knee procedures, so the true number is lower than the search numeric results suggest. Regarding CPKA, "bi-compartmental" and "bicompartmental" were used interchangeably, with the latter more commonly used to refer to knees where the patellofemoral joint and medial or lateral tibiofemoral joint had both undergone arthroplasty surgery. A significant number of papers referred to unicompartmental replacement without explicitly stating whether the medial or lateral compartment had been addressed. In the context of combined unicompartmental with patellofemoral arthroplasty procedures, there was rarely a distinction between medial and lateral unicompartmental replacement, which often needed to be established from the main text and led to significant confusion.

A very small number of papers were found to relate to ipsilateral medial and lateral unicompartmental replacement, without any real consensus. To describe this group of "non-total" knee procedures collectively, "compartmental" returned the greatest number of returns but was also elevated by papers referring to diseases of different compartments, rather than the procedures themselves.

The terminology and abbreviations used in the PubMed "best match" papers varied greatly, which are detailed in Table II.[4-18] There was little consensus on the terminology for ipsilateral medial and lateral unicompartmental arthroplasty, with some preferring bi-unicompartmental[4,5] while others used bi-uni[6] or bi-unicondylar.[7] This procedure was most commonly abbreviated to Bi-UKA or Bi-Uni. Others preferred to refer to all configurations as "bicompartmental", explaining the exact configurations in parenthesis.[8-10] In reference to the Uni/PFA combination, almost all used "bicompartmental" or less commonly bi-compartmental, with just one exception.[5] Most authors favoured "BKA" as the abbreviation for this procedure. However, all but one publication[9] failed to explicitly differentiate between medial or lateral unicompartmental arthroplasty when used in combination with patellofemoral arthroplasty, meaning that when the abbreviation was used, it was not immediately obvious whether the medial or lateral compartment had been resurfaced. With the exception of those papers describing monolithic components to simultaneously resurface the femoral condyle and trochlea, the majority of publications failed to state unequivocally whether both procedures had occurred under the same anaesthetic or whether a second operation had 'converted' a single previously performed partial arthroplasty to a combined procedure, as had exclusively been the case in one publication.[11] Every publication analyzed used parenthesis to explain their chosen abbreviation and the procedure in question, though there was little consensus or standardization.

Of the 30 orthopaedic speciality registrars familiar with unicompartmental, total knee, and patellofemoral procedures responded to the first survey, 28 responded. The terms "medial/lateral unicompartmental with patellofemoral replacement/arthroplasty" and "bi-unicompartmental replacement/arthroplasty" along with the abbreviations "UKA/PFA", "UKR/PFR", "BKR", and "BUKR" were found to be least favourable to the trainees and, therefore, were removed from the second survey. Of the 200 participants invited to respond to the second survey, 62 biomechanical engineers, 35 senior orthopaedic surgeons, 16 orthopaedic speciality registrars, and one industry representative took part. Overall, participants from the second survey preferred the term "arthroplasty" to "replacement", with 64% voting for "unicompartmental arthroplasty" in preference to "unicompartmental replacement". Similarly, 57% preferred "total knee arthroplasty" to "total knee replacement" and 57% opted for "patellofemoral arthroplasty" in preference to "patellofemoral replacement". Collectively, 54% of first and second

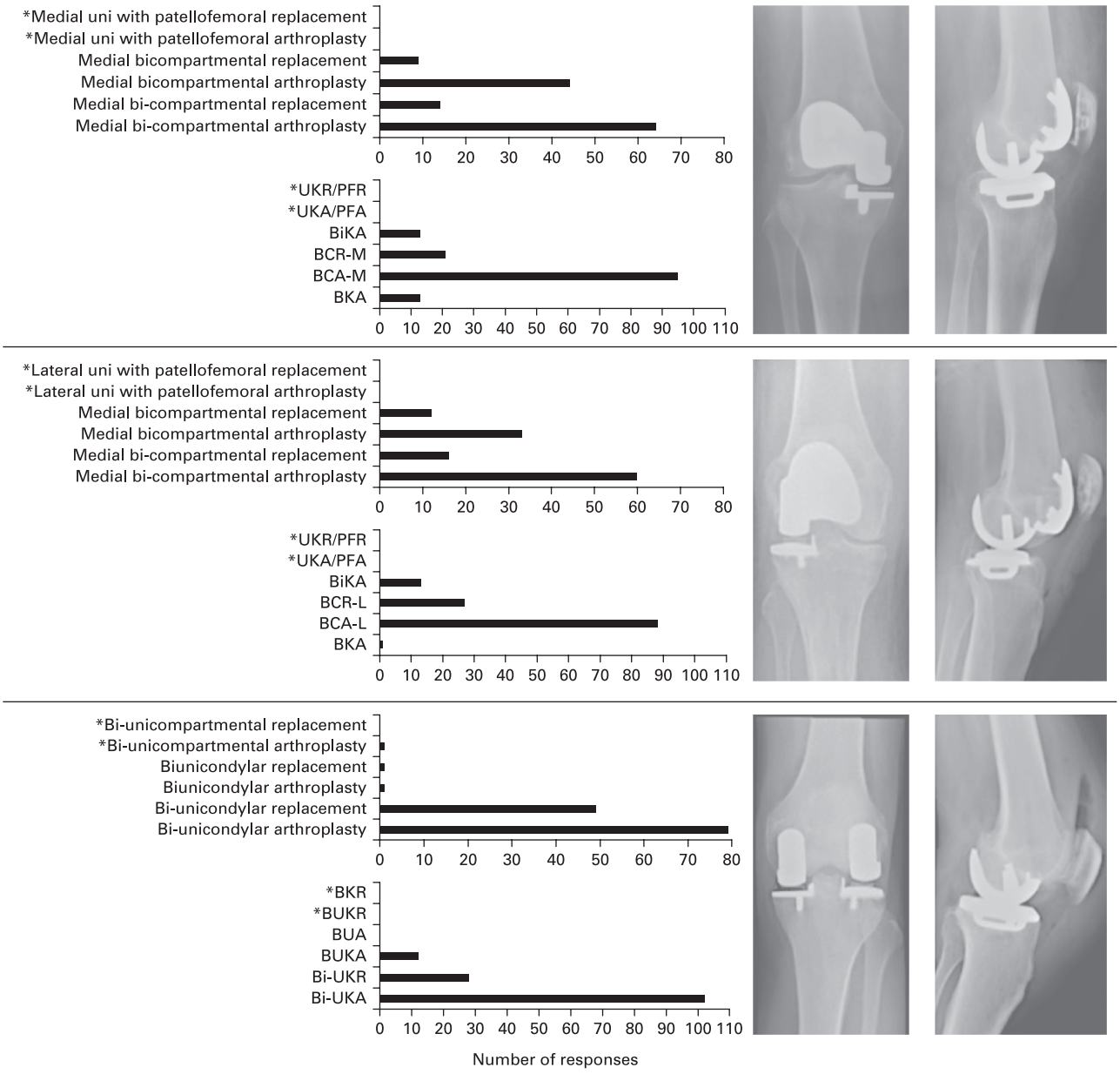

Fig. 1

Collective results of the two surveys completed by orthopaedic speciality registrars (survey 1) and orthopaedic surgeons, speciality registrars, and arthroplasty biomechanical engineers (survey 2) regarding terminology and abbreviations for combined partial knee arthroplasty procedures. *Excluded from second survey.

survey participants preferred "partial knee arthroplasty (PKA)" to "partial knee replacement (PKR)" (46%) when describing a single compartment procedure. Similarly, 54% felt "combined partial knee arthroplasty (CPKA)" was more intuitive than "combined partial knee replacement" (CPKR) (46%), "compartmental replacement" (0%), or "multi-compartment replacement" (0%) when describing the use of more than one small implant in the same knee.

Responses from the first and second survey are shown in Figure 1. Arthroplasty descriptions were preferred, as were hyphenated descriptions. "Medial bi-compartmental arthroplasty", "lateral bi-compartmental arthroplasty", and "bi-unicondylar arthroplasty" proved to be the most popular. Extended descriptions, for example "medial unicompartmental with patellofemoral arthroplasty" and other such combinations, were not found intuitive. Regarding abbreviations, survey respondents found "BCA-M", "BCA-L", and "Bi-UKA" preferable. "UKA/PFA", "UKR/PFR", "BUKR", and "BKR" received no votes. Two senior surgeons from the second survey thought that "Bi-UKA" referred to bilateral UKA, specifically one UKA in the right knee and one in the left. The term "BKA" was commonly used in the literature (Table II), but caused significant discussion; 14 speciality registrars (six from the first survey and seven from the second survey) and five senior orthopaedic surgeons from the second

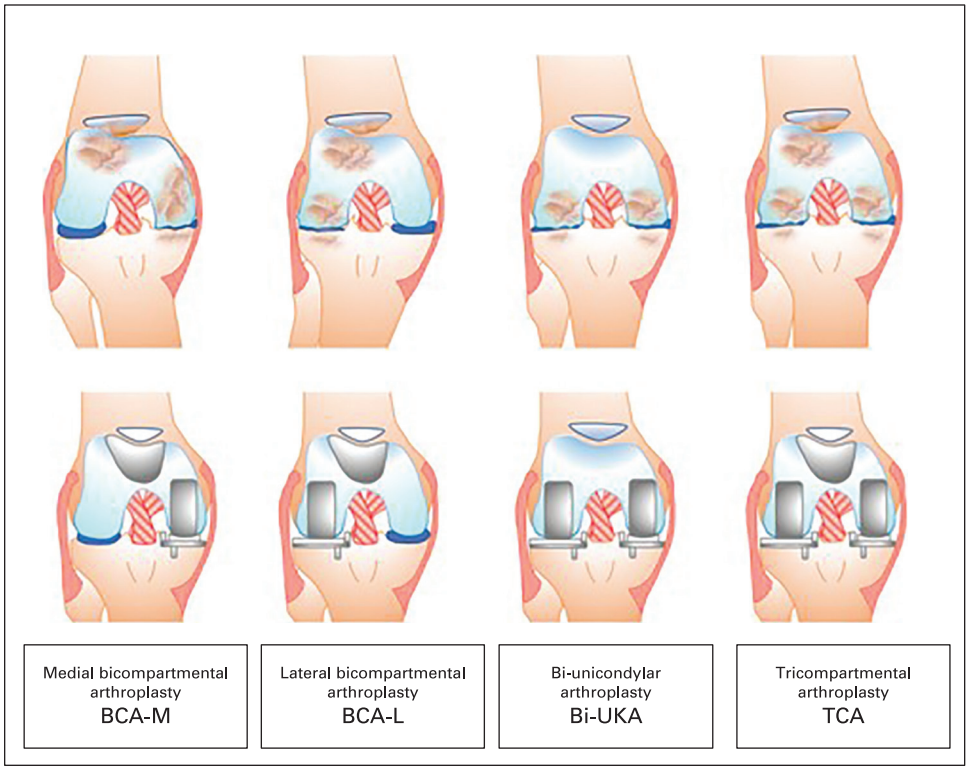

Fig. 2

Classification of combined partial knee arthroplasty (CPKA).

survey commented that they commonly abbreviated "below knee amputation" to "BKA", which they identified as possibly becoming a major source of confusion. All votes for "BKA" came from biomechanical engineers in the second survey, with no surgeons preferring this abbreviation to the others suggested.

Based on our findings, the following terms and abbreviations are recommended: "total knee arthroplasty (TKA); unicompartmental knee arthroplasty (UKA); patellofemoral arthroplasty (PFA); and partial knee arthroplasty (PKA), as the umbrella term for UKA or PFA. We propose the following terms: medial bicompartmental arthroplasty (BCA-M) to describe an ipsilateral medial UKA plus PFA; lateral bicompartmental arthroplasty (BCA-L) to describe ipsilateral lateral UKA plus PFA; bi-unicondylar arthroplasty (Bi-UKA) to describe ipsilateral medial and lateral UKA; and tricompartmental arthroplasty (TCA) to describe all three in combination (Figure 2). The most intuitive umbrella term for Bi-UKA, BCA-M, BCA-L, and TCA collectively is combined partial knee arthroplasty (CPKA).

Discussion

Currently, patients with multiple PKA implants within the same knee are not described in major implant registries such as the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man.[19] Unsurprisingly, inconsistent terminology runs throughout knee surgery literature, leading to confusion and uncertainty. Uniform descriptions and abbreviations are essential for clear communication and cohesive understanding. While TKR/TKA and UKR/UKA are generally understood, they are used interchangeably for no obvious reason. The term "arthroplasty" was used twice as often in the literature as "replacement" in both its complete and abbreviated form. Similarly, "arthroplasty" was preferred by our cohort of orthopaedic surgeons and biomechanical engineers. The term "replacement" overlooks resurfacing procedures, particularly in partial knee surgery, for example, which may be one explanation for the discrepancy.

The different configurations of CPKA were poorly defined with limited consensus in the scientific literature on appropriate abbreviations. Version 7.0 of the knee form K1 from the National Joint Registry, released in June 2018, allows surgeons to record that more than one PKA procedure has been performed in the primary setting.[20] Similarly, version 7.0 K2 now includes the option to record "partial replacement second compartment of knee", in recognition of the additional PKA.[21] As accurate analysis of this data becomes possible, many more publications in the field of CPKA are likely to follow. Clear definitions enable communication, allowing the reader to gain accurate insight into the literature as to exactly which procedure is being discussed. The interchangeable use of "bicompartmental" and "bi-unicondylar" with their numerous associated abbreviations, with and without hyphens, were found to be a significant source of confusion to the survey participants. Despite "bicompartmental" being found most commonly in the literature, the survey respondents leaned more towards the hyphenated form "bi-compartmental". The term "unicompartmental" is relatively undisputed, which is why its counterpart "bicompartmental" is used most often in the published form. However, our respondents also preferred the hyphenated "bi-unicondylar" term, which may have biased them towards other hyphenated forms. As seen with "uni-compartmental" and

"unicompartmental", history suggests that where there is no convention in the English language for the use of a hyphen, it tends to be abandoned over time, which is an argument to avoid its use for bicompartmental procedures, as is currently the case in the literature.

The abbreviations "Bi-UKA", "BCA-M", and "BCA-L" were preferred and considered intuitive to the procedures they describe, clearly differentiating between medial and lateral unicompartmental procedures and distinguishing the "Uni/PFA" combination from the ipsilateral medial and lateral unicompartmental procedure. The abbreviation "BKA", however, is long-established in English medical literature to describe a below-knee amputation.[22,23]

Our PubMed search results considered only study titles and abstracts, and, in doing so, may have inadvertently overlooked detailed definitions explained by authors in their subtext, limiting this study. The survey method stops short of a formal Delphi survey,[24,25] since the first group of respondents were not true experts in this specific area of arthroplasty surgery. The lack of joint registry data relating to combined procedures makes identifying surgeons regularly performing these procedures more difficult. In this paper, we have set out to design a classification system that is clear and user-friendly to the wider orthopaedic community. For this reason, we chose to survey orthopaedic surgeons and biomechanical engineers with a specialist interest in arthroplasty technology, as these individuals are stakeholders in the final outcome. Clear preferences were demonstrated by the respondents, giving us confidence that the proposed classification system will be acceptable to users. The options offered to participants came from frequently cited papers in this field, but there are no doubt other alternatives, which this study did not consider. The respondents in the second-round survey were attending an international conference, in London, and conducted in English; therefore, the relevance of this study to non-English speaking practices and those not based in the United Kingdom may be limited.

A consensus of orthopaedic and specialist biomechanical engineering opinion supports the adoption of clear, intuitive classification system, in order to enable the accurate description of the status of patients with multiple PKA implants within the same knee.

Accurate classification of these procedures will improve written and verbal communication between surgeons, allied health professionals, and patients, making certain that the patients understand the arthroplasty options available to them.[26] A robust classification system ensures accurate clinical coding for remuneration, individual surgeon logbook data and joint registry audit, to meet modern patient safety standards.

Take home message

- Current literature offers no consensus on classification of combined partial knee arthroplasty.
- Clear terminology enables safe and effective communication when describing these procedures.
- A clear and intuitive classification system is suggested.

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R. J. van Arkel: Analyzed the data, Wrote, reviewed, edited, and revised the manuscript.
J. Cobb: Conceived the study, Reviewed the data, Reviewed, edited, and revised the manuscript.

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